Computer Software Support to enable Autistic Users to Manipulate Website Design

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Abstract: - The use of mobile devices for day to day interactions for both professional and personal purposes has exploded in recent years, with most people fully dependent on these devices. As these devices are now cheaper and part of main stream society, some users do not necessarily possess the correct knowledge or mental faculties to interact with these devices correctly. This, in turn, exacerbates limitations within these devices and prevents select users from experiencing the devices content in the same way as others. An example of these limitations would be screen size and the scaling of content to fit such a smaller workspace. As a result, design is a major factor in providing beautiful yet functional spaces, but good functional design layout does not necessarily indicate accessible content. The purpose of this study is to examine Autism and technology, focusing on the effects developers' design decisions have when interacting with mobile web content.

Key-Words: - Autism, Internet, Mobile web, Mobile devices, Apple, Google, Gestalt Principles, WCAG, Native Applications, Hybrid Applications.

1 Introduction

Internet usage has surged over the past two decades it has been estimated that Internet users increased from 35million to 2.8billion. This vast increase in users accounts for around 39% of the global population having some form of access to the internet [1]. Mobile Phone (alternatively known as Cell Phone) users have also seen similar trends, seeing a 73% increase in usage in as many years. It has also estimated that over the past two decades there were around 5.2billion mobile phone users [1]. With both trends running side-by-side over the last two decades we see a transition in how the web is being used. Cui et al, from the Nokia Research Centre, define mobile web as "being able to access online content any time anywhere making if far more diverse than the static Desktop counterpart" [2].

This diversity and flexibility then leads to the concept as to why both smartphones and tablets are growing within the search market (where search market queries are conducted via app or mobile browsers to a search engine), now accounting for 29% of all search activity [3]. In 2015, Google reported that of the 100billion search queries conducted each month by its users, 50% of these were conducted on mobile devices [4]. With mobile web taking up 8% of the time that users spend on mobile phones, which is estimated around 48 minutes a day [3].

General web browsing is clearly diversifying away from static browsing/desktop browsing. Posing the question, "has the way we browse changed?" Cui et al [2] gathered user data of 547 users accessing the web. They defined 3 types of browsing to seek information: Fact finding, information gathering and casual browsing.

- Fact Finding - Using a mobile web to seek for a piece of small and specific information;
- Information Gathering - Collection of information from multiple sources to achieve a broad goal;
- Casual Browsing - General access to information with no specific goal or purpose.

In [3] a study was undertaken to look at comparisons between desktop and mobile browsing and notes that for the purpose of "seeking information" occurs within both environments.

Mobile web does have the main limitation of screen size, and that interaction with smaller displays may not provide the same experience as a conventional desktop. Jones et al conducted [5] research into interaction with smaller displays.

They concluded that smaller screens did slow down reading time but more interestingly not significantly.

With such research investigating the use of mobile devices, user experience researchers such as Nielsen [6] suggested that scrolling (which would be inherent with small mobile device screens) would be a "usability disaster". However, Nielsen in a further study [7] concluded that scrolling was not a major issue for users. Remarkably, he suggested that "changes in behaviour is due to users experience with the web" and that users will "get used to scrolling and find it easy to deal with".

The consideration that aspects of the web are no longer usability disasters because users "find it easy to deal with" leads us into to the question: although the average user may find it easy to adapt to changes would an autistic user be able to adapt in the same way?

2 Autism and Technology

Throughout this study the term Autism will be used interchangeably with Autistic Spectrum Disorders (ASD). The term ASD is more appropriate when considering people with Autism as it encompasses the full scale in which users fall within. It is important to highlight that Autism can affect people to different degrees. Autism shall be used as the generic term. In the scope of this study Autism is described as 'a lifelong developmental disability, which affects how a person communicates and relates to other people'. It also changes how they experience the world around them [8]. In [8], Autism UK, discusses how autistic users experience the world differently and have great difficulty making sense of the world. Consequently, this suggests that the use of mobile devices and mobile web would also become difficult as the autistic user attempts to navigate around the web's different pages, how they interact with different menu systems and how they perceive icons. There are multiple symptoms that define a user as being autistic. These symptoms then contribute to how autistic users interact with the outside world. For the scope of this study, we will consider two of the major autistic symptoms which could then directly relate to how they interact with mobile web. The first being sensory perception abnormalities and the second being detailed focused processing.

2.1 Sensory Perception Abnormalities In Autism

Sensory perception abnormalities are described as hyper-sensitivity or hypo-sensitivity to stimulation such as sound, vision, touch, taste and smell. Sensory perception abnormalities could also include kinaesthetic movement, where depths of objects are misjudged or elements are considered moving, when in fact they are still. Sensory overload is considered to be the interactivity with multiple senses at the same time, which results in loss of information, or in some situations sensory turnouts where sound and vision stop or "blank out" [8].

O'Neill and Jones [9] documented accounts from autistic users and their experiences with sensory perceptions. Participants noted that visual hypersensitivity, such as bright colours, were "painful" on the eyes, and that colours such as red "hurt". They also noted that overloading could occur when there was too much stimulation of senses. Typically, when one to two senses were being used at the same time, resulting in pain and discomfort to the user. The use of multiple senses also resulted in users being unable to process the information and becoming engrossed in one aspect of a "situation". An autistic user attempted to provide a description of the phenomenon known as "over-selectivity".

"I have trouble processing many things at once ... most people have a mind like a flashlight, with an area of high focus, and a larger area of partial awareness; my mind is more like a laser pointer, that highlights only a single small dot" [10].

Sensory perception abnormalities in Autism as described in [9] and [10], show that some autistic users struggle with colour, and the use of multiple senses at the same time. Hence, we can identify that web pages that use dramatic colours as background images or include multiple sensory elements such as video and sound could cause great discomfort.

2.2 Detailed Focused Processing

Detailed Focused Processing (DFP) or "weak central coherence" is suggested to identify ASD, which indicates a failure to extract global meaning from content. Assumptions cannot be made as to what an autistic user is directing their attention to. However it is likely to be local information - local information can be aspects of an object such as colour, shape, structural details [11], or elements around the global meaning and as a result, the user loses out of the full picture or expressed meaning [12].

Dautenhahn [11] highlights that virtual

They also noted that if users read/browsed chunks of text, then their performance should not degrade.

environments are well suited to supporting autistic users to deal with DFP. Dautenhahn's research is centered around the support of autistic children with the use of robotics. A key concept was the use of virtual environments to help support different aspects of the "world", and that through these environments the "world" can be dynamically changed depending on individual requirements to present content differently to suit.

DFP within an everyday environment means that users are not able to fully capture content as intended. This leads to the question: Is it possible to use DFP to assist with producing a software application that will improve users interaction and understanding of that software application?

Results from a study conducted by Shah and Frith [13] identified that "autistic subjects appear to process unconnected stimuli, outside a meaningful context, with remarkable efficiency". They noted that strong Gestalt qualities within designs are "favoured" by sufferers of weak central coherence. (Gestalt principles are discussed in section 2.4.) Interestingly, they recorded results of accuracy of between 96% and 100% during design construction [13].

2.3 Benefits Of Mobile Technology

In the previous sections we have highlighted two main limiting factors that could impede on how autistic users interact with technology and mobile web. Very importantly there are also some benefits that comes with mobile technology which, in turn, elements that could be reflected within a specific web browsing software application. Research conducted by DELSBU [14] included studies on Autism and Cognitive Architecture which showed that mobile technology was very desirable as it would be consistent and predictable. Furthermore, it would provide the user a comfortable environment with less social demands.

DELSBU in [14] also stated that mobile technology was culturally accepted. For example, to external audiences it would look as if an autistic user was using a standard mobile phone, which would then assist with removing any unnecessary stigma.

The interactivity with mobile web would have greater impact if it was possible to identify that autistic users would actually use the technology. Hardy [15] demonstrated that ASD users showed an interest and engagement with computers which assisted with impacting on their sense of achievement and could increase their self-esteem. Hence, we consider that the use of mobile devices which allow interactivity with web content would be accepted by users with ASD. This is because there would be no appearance showing that the user has any disabling issues, as mobile devices are now intertwined throughout society and our individual lives.

2.4 Gestalt Principles Of Design

Research into Autism and technology has revealed the importance of design and colour choices to assist with not overloading and overwhelming the user as cited by Shah [13].

Chapman and Chapman's book [16] investigate different web design concepts and highlight that we, as users, look for patterns and structures based on grouping organised visual information. Gestalt's key principles of design are:

- Proimity - Elements that are close together that are identified as one group;
- Similarity - Objects look similar to another object;
- Closure - To complete a visual pattern from incomplete information.

Principles such as these assist with creating software applications that begin to answer a question posed in the introduction on what is "ease of use"? If the design of a software application is similar to a user's past experiences and it draws on defined proximity methods such as menu bars, this should continue to support ASD users understanding of the new software application.

2.4 Web Content Accessibility Guidelines

Web Content Accessibility Guidelines (WCAG) [18] are developed by the W3C [19] in cooperation with multiple individuals and organisations from around the world. WCAG are currently the industry standard used by developers to make web content accessible to people with a range of disabilities [18]. The guidelines attempt to cover a variety of disabilities from visual, auditory, physical, speech, cognitive, language and neurological. Importantly, the guidelines highlight that it simply would not be possible to encapsulate all "types, degrees and combinations of disabilities" [18].

The guidelines are sub-divided into 4 main layers:

1. Principles - defined as the "foundation" of web accessibility:
   - Perceivable - Users need to be aware of the information being presented;

- Operable - Navigation and components interaction must be actions that the user can perform;
- Understandable - content or operations cannot be confusing and go beyond a users understanding;
- Robust - technologies can change advance but the content should still be accessible.;

2. Guidelines - A complete list of 12 guidelines of goals in which authors should work towards. These guidelines are used to provide a framework to assist with understanding success criteria;
3. Success Criteria - Each guideline has success criteria. Success criteria have been specifically designed to meet the different needs of users. They have been defined in three levels - A, AA and AAA (highest);
4. Sufficient and Advisory Techniques - Each guideline and success criterion has additional techniques classed as sufficient and advisory. In this context, "Sufficient" means meeting the success criteria and "advisory" goes beyond the individual success criteria for enhanced accessibility.

2.4.1 WCAG Issues

The fact that WCAG were created shows positive progression with making accessible content available for all, regardless of disability. The main problem seen with this is that with a vast number of web pages available online, who is enforcing WCAG and what are the repercussions of failing to comply?

Power [20] identified the guidelines are only part of the story when studying accessibility problems that are encountered by blind users. Power concluded the following:

- 30% of websites exaggerated their WCAG status - either A, AA or AAA;
- 22% of site owners were not aware of any accessibility guidelines;
- Out of 100 websites 45% of users reported issues with a site that were not covered by WCAG;
- Following the release of the WCAG no improvements seem to have been made to web accessibility. Research of 30million web pages tested against the automated elements of Success Criteria found that only 4% met the relevant criteria.

It is disappointing to see from Power's research that the WCAG are not being used fully by developers or in some cases simply ignored. Furthermore, it is evident that frequently when the guidelines are used they are used poorly and in many cases there appears to be a large range of outstanding issues that should be covered but in reality are not.

Therefore, we consider that the WCAG alone are simply not enough to achieve accessible content. We consider that development of a software application which puts the control of the design and layout into the hands of it users who have particular disabilities may prove a better alternative.

3 Native Applications v Hybrid Applications

Currently, development of mobile software applications has three main streams. These are native applications, web applications or hybrid applications. We remove web applications from our study as any improvements to ASD users would be required to run within a browser. This would mean that the ASD user would then have to run an environment within their current browser, which potentially would prove very confusing and hence of no benefit to the ASD user.

3.1 Native Applications

A software application is stored on a user's device which then allows the application to interact with hardware features and functionality of that device. The use of these features makes the application more responsive and provides specific control over the user interface [21].

Specific features that could be leveraged from the hardware could be the use of vibration as haptic feedback to button selects. As these features are specific to a device, this would not be possible with a hybrid application. Additionally, specific user device information would not be possible to capture. Such as, operating system information, which could be used to provide feedback to developers on the "issues" ASD users are having with their sites and what devices are causing the biggest problem. (Problems in relation to screen size etc.) Again, access to specific hardware/native operating system information would not be accessible via hybrid applications.

It is worth noting that commonly hybrid applications and web applications are not security conscious. This is due to requiring constant connections to a server, in which information would be passed which could potentially become

compromised.

3.2 Hybrid Applications

Hybrid applications are cross platform solutions that use abstraction of Native APIs (Application Programming Interface) which allows developers to write the software application with only JavaScript and HTML (Hyper Text Markup Language). The use of Hybrid applications removes the requirement to re-design the software application for each operating system in which runs [21].

A major issue with native applications is that the programming language used has to be specific for each particular operating system. This means that a greater number of experienced developers will be required for each independent Operating System (OS). Unlike hybrid applications, where defined web standards can be used such as HTML, JavaScript, and CSS (Cascading Style Sheets) [19], which can run across any device regardless of default OS.

As a result of this, it then means that hybrid applications provide a more cost-effective solution as there is only one iteration of development, one iteration of testing and no requirement for a developer to be competent across multiple programming languages.

The major issue with hybrid applications is that they currently achieve poor performance when compared against native applications. This is a direct consequence of additional overheads and a great deal of auto generated code [21].

A further complication is the code that is generated to make an application bootable for different OSs such as the Android OS or the Apple iOS is "wrapped" around the HTML and CSS. The code would, therefore, become difficult to understand and maintain.

3.3 Our Chosen Application Type

Based on the advantages and the disadvantages of native applications and hybrid applications we consider that a native application would be the more appropriate for ASD users. Our choice is really because of the additional overheads placed on hybrid applications.

We acknowledge that hybrid applications have a number of very important advantages and that in following the hybrid application approach we would lose interaction with the user's with hardware APIs such as vibrate, we would also not be able to gain system information which is paramount to the identification of a user's device. Consequently, we will include platform analysis to identify which device platform would be most suitable for creating a Proof of Concept (POC).

3.3 Platform Analysis

The mobile industry is dominated by two main players - Google and Apple. As of February 2016 collectivity they owned 91.93% of the market [22]. It would therefore be wise to use one of these platforms to create software applications.

Initially we investigated adoption rates of the different operating systems. We consider it to be desirable when designing a software application to take advantage of the latest features and APIs available. However, an issue that could arise is if a framework or API used is not available on an older iteration. Based on this, adoption rate of a new OS is vital.

Developer information shared by both Apple and Google showed that Apple currently has 79% of its users running the latest version of iOS, at time of writing this is 9.3 [23]. Interestingly, Google currently has only 2.3% of its users running the latest version, at time of writing this is Marshmallow [24].

Our findings suggest that developing for an iOS would be a more suitable choice. Although adoption rates are better for iOS, a further and main factor is the accessibility options available on the OS.

When attempting to find definitive proof of what operating system would be best for users with disabilities, our findings show that it is subjective depending on the different disabilities and the different personal company perspectives. As an attempt to identify which OS would be best for an ASD user we have conducted a study of three Android devices and three Apple devices. We were particularly interested in the the range of accessibility options available, consistency of their functionality and ease of use to the ASD user.

We used a wide range of different propriety devices which are currently popularly available: an iPhone 5c running iOS 8.2.3, an iPhone 6 running iOS 9.3, an iPhone 6s running iOS 9.2, a Motorola Play running Lollipop, 1+1 running Marshmallow and a Vodafone Smart Prime 6 running Lollipop .

On initial testing of accessibility options all three of the iPhones have the same accessibility options which are all categorised exactly the same and hence they show complete consistency. Also, on initial testing of accessibility options across the Android devices, each device had slightly different

accessibility options based on propriety preferences. There was not any defined structure with some options appearing in different places. As seen on 1+1 where high contrast text and magnification gestures are included under system but are not in both Motorola Play and Vodafone Smart Prime 6. A further example is that both Motorola Play and Vodafone Smart Prime 6 had colour inversion but 1+1 did not.

Predictability of functionality also varied on Android. Both Motorola Play and 1+1 performed well with turning on magnification, voice control and font size increase. The Vodafone Smart Prime 6 performed less favourably, with issues with turning magnification on and off and poor voice control.

iOS functionality testing identified that all options operated in exactly the same way across all three different devices, with the same ease of use for activating and deactivating each option. Additional iOS includes additional functionality that currently is not available on Android. Two particular features that could be useful for autistic users is Guided Access and Assistive Touch [25]

- Guided Access - Specifically designed to assist autistic users with sensory and attention issues to stay focused. Guided Access disables the use of the home button and restricts users to one application;
- Assistive Touch - Allows changes to multi-touch screens to suit users preferences. It also includes the ability to allow users to create their own gestures which can then be used for navigating [25].

Based on adoption rates of iOS and the range of accessibility options available, we consider it would be better to use iOS as the main platform for ASD users device improvement software applications.

4 Current Solutions

With an estimated 1.5million applications currently available on Apple's App Store correct as of August 2016 [26], we wondered if there are currently any solutions to support autistic users or similar editor tools which could provide suitable assistance to an autistic user. This would provide validity to how well particular software applications worked at manipulating views. We conducted a study into three potential solutions. Based on information from LexiConnect we tested each solution on the top 6 visited sites in the UK correct as of August 2016 [27]. We chose to test across the most popular websites on the Internet to simulate real life usage of the smartphone with these three applications: Safari Reader, Readability and Stylebot.

4.1 Safari Reader

During the World Wide Developers Conference in 2010 Apple announced a new feature to both OS X and iOS called Safari Reader. Reader was designed to manipulate the view of a website and even change font sizes and styles to make for a better reading experience. This also included the removal of "distracting" elements within a web page such as adverts [28].

4.2 Readability

Readability is a software application created in 2009 that offers a "clean and comfortable" reading view. It converts web pages into articles which can be saved for later, or transferred to Amazon Kindle if preferred [29].

4.3 Stylebot

Stylebot is a Google Chrome Extension that when activated allows users to change the appearance of websites with specific tools such as font, colour, visibility and margins.

4.4 Our Observations

We found a number of interesting observations from testing the three potential solutions.

4.4.1 Safari Reader Observations

Safari reader failed to work across all of the sites it was tested on. The Safari reader option was not even available to produce a partial solution. Further testing found Safari reader only seems to work with sites that is solely text such as Wikipedia and other blogging sites. As a result Safari Reader provides no suitable overall support to ASD users to manipulate sites.

4.4.2 Readability Observations

Readability fared better in testing than Safari Reader providing some good changes to sites such as the BBC. The issues with Readability was that the application did not work across all sites and for sites that it did work frequently content was missing, or the layout was disjointed rendering most converted sites unusable. A further issues with Readability was that content had to be sourced via a mobile web browser first, then shared from the web browser to Readability. This, as a solution, then made the

process very clunky and significant time was spent waiting for the application to capture the content to push to the application. This lead to continual flicking between the web browser and the application. Hence, we do consider Readability to be beneficial to the ASD user.

4.4.3 Stylebot Observations

Stylebot performed excellently across all the websites tested, allowing edits to the pages layout and design. A major limitation with Stylebot is it only works within the desktop Chrome browser, and is not currently suitable for mobile devices. Further complications with Stylebot is that there are many different settings and features which can be changed for each individual site. As a result, it could be very overwhelming to deal with by the ASD user.

This being said, Stylebot does have a lot of major functionality which would be ideal for a mobile application:

- Adjusting;
- Font size;
- Font family;
- Line spacing;
- Text colour;
- Background colour;
- DIV visibility - (DIV means division or a section in an HTML document).

Features such as background colour and DIV visibility manipulation would support ASD users in having an improved web browsing experience. Stylebot has also provided a functional example that it should be possible to produce an application to make changes to a website.

4.5 Result Comparison

Testing was completed via an iPhone 6 running iOS 9.3 for Safari Reader and Readability. Due to compatibility issues of Stylebot testing was completed on a Mac running OS X (10.11.3). Our findings our presented in Table 1.

Table 1: A comparison of usage three current solutions

Tested Site	Safari Reader	Readability	Stylebot
Google	Reader functionality not available.	Successfully rendered content within app - but layout is poor.	Excellent control to edit a range of options including fonts, colours, margins and many more.
YouTube	Reader functionality not available.	Successfully rendered content within app - but layout is poor.	Excellent control to edit a range of options including fonts, colours, margins and many more.
Facebook	Reader functionality not available.	Failed to render site to any standard.	Excellent control to edit a range of options including fonts, colours, margins and many more.
Amazon	Reader functionality not available.	Successfully rendered content within app - layout good but all site functionality lost without returning to Amazon.	Excellent control to edit a range of options including fonts, colours, margins and many more.
eBay UK	Reader functionality not available.	Failed to render site to any standard.	Excellent control to edit a range of options including fonts, colours, margins and many more.
BBC UK	Reader functionality not available.	Successfully rendered content within app - layout excellent but some text content lost.	Excellent control to edit a range of options including fonts, colours, margins and many more.

5 Conclusion

Mobile platforms are continuing to gain traction as a device of choice for web browsing. We conclude that ASD users struggle with identifying and gaining the main content of information and while designers and developers continue to provide lack of support to ASD users then their problems with mobile technology will continue.

ASD users suffer from sensory perception and detailed focused processing issues which means they struggle with colours used on backgrounds and multiple sensory elements such as video or sound. DFP is a failure to extract global meaning from content. DFP can be used alongside strong Gestalt principles to produce an application using known “stimuli”. The use of technology can remove any unnecessary stigma and improves engagement with an ASD user. WCAG alone simply is not enough to achieve accessible content that is suitable for ASD

users.

We consider that the identified application type should be native to device, that the identified operating system should be an iOS and finally that functionality used within Stylebot proves that manipulation of sites temporarily is possible and provides good supporting functionality to manipulate web views.

We are already in the development stages of a software application aimed at ASD users using mobile devices that will fulfill the criteria mentioned above. We consider that such a software application will be beneficial to the ASD user. Our future software application will have the capability to remove multiple sensory elements and also to remove dramatic colours from backgrounds. It will also take familiar icons and relate them to functionality consistent with other software applications. Hence, we will have a substantial degree of certainty of knowing that an ASD user would understand the application software usage, regardless of whether they understand the surrounding content (in relation to application this surrounding content would relate to a web pages content).

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